Spring 2004

# Physics 137B Section 1: Problem Set #3
# Due: 5PM Friday Feb 13 in $2^{nd}$ floor LeConte-Birge Cross-Over

**Suggested Reading for this Week:**

- Bransden and Joachain (B& J) sections 8.1-8.2
- B& J section 12.1

**Homework Problems:**

1. B& J problem 8.6
2. B& J problem 8.7
3. B& J problem 8.9
4. Consider a particle confined in a two-dimensional infinite square well with faces at $x = 0$: $x = L$ and $y = 0 : y = L$. The doubly degenerate eigenstates appear as
$$\psi_{np}(x,y) = \frac{2}{L}\sin\left(\frac{n\pi x}{L}\right)\sin\left(\frac{p\pi y}{L}\right)$$
with energy $E_{np} = E_1(n^2 + p^2)$. How do these energies change under the perturbation
$$H' = 10^{-3}E_1\sin\left(\frac{\pi x}{L}\right)$$
5. The Hamiltonian for a quantum mechanical dumbbell is
$$H = \frac{L^2}{2I}$$
where $I$ is the moment of inertial of the dumbbell. The eigenstates of this system are thus
$$E_\ell = \frac{\hbar^2\ell(\ell+1)}{2I}$$

and for a given $\ell$ is $(2\ell+1)$-fold degenerate. (See B& J pages 290-292 if you are not familiar with this problem.) In the event that the dumbbell is equally and oppositely charged at its ends, it becomes a dipole. The interaction energy between such a dipole and a constant, uniform electric field $\vec{E}$ is

$$H' = -\vec{d} \cdot \vec{E}$$

where $\vec{d}$ is the dipole moment of the dumbbell. Show that to terms of first order, this perturbing potential *does not separate* the degenerate $E_\ell$ eigenstates.